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MORPHOMETRIC CHARACTERISTIC OF OESOPHAGUS AND INTESTINE IN BLACK SCOTER, *MELANITTA NIGRA* (ANSERIFORMES), WINTERING IN THE POLISH BALTIC COAST

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Morphometric Characteristic of Oesophagus and Intestine in Black Scoter, *Melanitta nigra* (Anseriformes), Wintering in the Polish Baltic Coast. Działa-Szczepańczyk E. — The material for the studies was oesophagi and intestines of 52 individuals of the Black Scoter *Melanitta nigra* Linnaeus — 32 males (5 immature and 27 adult ones) and 20 females (11 immature and 9 adult ones). The following morphometric features of the alimentary system were analysed: oesophagus length EL and weight EW, duodenum length DL, combined length of jejunum and ileum JIL, combined length CBL and weight CBW of both caeca, small intestine length SIL, and combined length of rectum and cloaca RCL. In the analysis the sex and age of birds was taken into consideration, as well as their body sizes characterised by four parameters: body weight BW, body length BL, sternum length SL, and tarsus length TL. Despite the revealed significant dimorphic differences in the features describing the size of black scoters' bodies, only in EL, EW and RCL significant differences between males and females were recorded. No ontogenetic differences concerning black scoters' body sizes within each sex occurred. Such differences were, however, revealed both in the group of males and females with reference to EW, JIL, and CBW. A positive correlation for the relation of CBL to SIL and a negative one for the relation of EW to both parameters of caeca and to JIL were shown.

Key words: Black Scoter, *Melanitta nigra*, morphometry, oesophagus, intestine.

Морфометрическая характеристика пищевода и кишечника синьги, *Melanitta nigra* (Anseriformes), зимующей на польском побережье Балтийского моря. Дзяла-Щепаньчик Э. — Исследованы пищеводы и кишечники 52 особей синьги *Melanitta nigra* Linnaeus — 32 ♂ (5 молодых и 27 взрослых) и 20 ♀ (11 молодых и 9 взрослых). Проанализированы с учетом пола и возраста птиц, а также размеров их тела следующие морфометрические характеристики пищеварительной системы: длина (EL) и масса (EW) пищевода, длина двенадцатиперстной кишки (DL), общая длина тощей и подвздошной кишек (JIL), общая длина (CBL) и масса (CBW) обеих слепых кишек, длина тонкого кишечника (SIL), а также общая длина прямой кишки и клоаки (RCL). Последняя охарактеризирована с учетом 4 параметров: массы (BW) и длины (BL) тела, длины грудины с килем (SL) и длины цевки (TL). Помимо выявленных достоверных диморфических отличий в размерах тела синьги, значимые отличия между самцами и самками установлены только касательно EL и EW, а также RCL. Не выявлено онтогенетических различий размеров тела синьги между самцами и самками. Вместе с тем обнаружены такие отличия, как в группе самцов, так и самок относительно EW, JIL и CBW. Определена положительная корреляция CBL с SIL, а также отрицательная — EW с обоими параметрами слепых кишек, а также с JIL.

Ключевые слова: синьга, *Melanitta nigra*, морфометрия, пищевод, кишечник.

Introduction

The morphology of oesophagus and intestine of Anseriform birds, like the remaining representatives of the class Aves, show large interspecific variability. One of the reasons is that Anseriform birds are represented in all three trophic groups — herbivorous, predatory, and species feeding on food of mixed, animal and vegetable, origin. Moreover, digestive canals of Anseriform birds are characterised by large morphological plasticity in relation to diet change in time (Miller, 1974, 1976; Paulus, 1982; Drobney, 1984; Kehoe et al., 1988). This characteristic is one of the fundamental reasons of the individual variability of digestive canal structure in this group of birds. This variability comes out in morphometric features of digestive organs, such as length and weight — particularly of oesophagus and intestine, which are the longest parts of the digestive canal.

The Black Scoter *Melanitta fusca* is a member of the order Anseriformes, suborder Anseres, family Anatidae, subfamily Anatinae, tribe Mergini (del Hoyo et al., 1992). It is a migrating species — nesting in taiga and wintering on non-freezing seas of Europe. In summer it feeds on mixed food with larger share of food of animal origin; in winter it is a determined predator and mainly feeds on bivalves, snails, other invertebrates, and small fish (Stempniewicz, 1986; del Hoyo et al., 1992; Tomiałoć 1990).

The purpose of this study is to present a morphometric characteristic of individual parts of the Black Scoter's intestine taking into consideration the birds' sizes, ages, sex, and their diet.

Material and methods

The study encompassed oesophagi and intestines of 52 individuals of the Black Scoters *Melanitta nigra* Linnaeus— 32 ♂ (5 immature and 27 adult ones) and 20 ♀ (11 immature and 9 adult ones). The birds were obtained in winter and autumn seasons in the years 1993−1999 in fishing ports of West Pomerania province in Dziwnow, Miedzyzdroje, Miedzywodzie, Wiselka, and Swinoujscie. After determining the sex and ages of the black scoters, four measurements describing their body sizes were made: body weight BW (exact to 50 g) and three linear measurements: body length BL, measured from beak to the end of rump (soft tape, exact to 0.5 mm), sternum length SL (exact to 0.5 mm), tarsus length TL (exact to 0.1 mm) — made according to Dziubin and Cooch's proposal (1992). The whole of alimentary system, after taking out of a body, was spread, mesentery and fat tissue were removed, and then it was put in a straight line. The following measurements were made: oesophagus length EL and weight EW, duodenum length DL, jejunum and ileum length JIL, combined length CBL and weight CBW of both caeca, combined length of rectum and cloaca RCL. Oesophagus length EL was established by measuring the section between an oral cavity and clearly visible dividing line between the tissue lining an oesophagus and the tissue lining a proventriculus. A duodenum, which is a first section of a small intestine, was measured from flexura duodenojejunalis determined by the presence of arteria coeliaca (exact to 0.5 cm). The combined length of jejunum and ileum JIL and the combined length of intestinum terminale and cloaca RCL was measured exact to 0.5 cm. The measurement of the combined length of caeca CBL was made exact to 0.1 mm. The mentioned linear measurements were made using Leopold's method (1953). Moreover, oesophagus weight and both caeca weight were determined (exact to 0.01 g) after cleaning the organs off chyme and drying with filter paper. The study also analysed the combined length of small intestine SIL, which was the sum of duodenum length and jejunum and ileum length.

The obtained results were worked out statistically. Basic characteristics were calculated: arithmetic average, standard deviation, coefficient of variation for all analysed parametric features of black scoters. Relationships occurring between the four features characterising the body weights of the studied birds and the parameters of oesophagus and intestine were also studied. To this end appropriate Pearson's coefficients of linear correlation (r) were established. The significance of differences between males and females, and age groups of the birds in average values of the analysed parameters was determined by means of t-Student test.

Results

The following average values of the analysed measurements of digestive canal in the studied 52 individuals of black scoters were obtained: oesophagus length — 168.1 mm, the organ's weight — 7.04 g, small intestine length — 1694.9 cm (including duodenum length — 301.1 cm and the combined jejunum and ileum length — 1400.4 cm), the combined length of terminal intestine and cloaca 116.8 cm, both caeca length — 40 mm, and their weight — 0.23 g (tabl. 1).

The group of males and females differed significantly in all four average measurements characterising the birds' body sizes. However, with reference to the digestive canal parameters, drakes and ducks only differed in oesophagus, rectum and cloaca sizes, whereas in males higher values of those organs measurements were recorded (tabl. 1).

Ontogenetic differences within each sex were not evident in the measurements describing the birds' body sizes. Such differences were noticed in the measurements of oesophagus and some measurements of intestine. Young drakes differed significantly compared to adults in oesophagus length and weight, caeca weight and length, and the combined jejunum and ileum length; in young individuals oesophagus parameters reached lower values and intestine parameters were higher than in adult individuals of this sex. Young females had significantly heavier caeca, bigger combined jejunum and ileum length, and small intestine length than adult ducks. The oesophagus in this group of ducks was characterised by bigger weight in adult individuals than in young individuals (tabl. 2).

Table 1. Differences in absolute body and oesophagus and intestine parameters between males and females of the Black Scoter *Melanitta nigra*

Таблица 1. Отличия в абсолютных параметрах тела, пищевода и кишечника между самцами и самками синьги

Measurement	x̄ ± SD CV		M VS. F	x̄ ± SD CV M + F (n = 52)
	M (n = 32)	F (n = 20)		
BW, g	1345.9 ± 99.0 7.3	1183.0 ± 84.5 7.1	t = 6.10 p < 0.0001	1283.3 ± 122.4 9.5
BL, mm	429.8 ± 11.5 2.7	407 ± 10.69 2.6	t = 7.14 p < 0.0001	421.1 ± 15.8 3.7
TL, mm	45.2 ± 1.2 2.7	43.1 ± 1.3 3.1	t = 5.84 p < 0.0001	44.4 ± 1.6 3.7
SL, mm	100.7 ± 5.6 5.6	93.4 ± 4.5 4.8	t = 4.87 p < 0.0001	97.9 ± 6.3 6.4
EL, mm	171.4 ± 10.3 6.0	162.7 ± 15.1 9.3	t = 2.46 p < 0.05	168.1 ± 12.9 7.7
EW, g	7.57 ± 1.35 17.8	6.19 ± 1.37 22.2	t = 3.54 p < 0.0001	7.04 ± 1.50 21.3
DL, mm	307.6 ± 38.3 12.4	290.5 ± 38.1 13.1	NS	301.1 ± 38.8 12.9
JIL, mm	1372.2 ± 146.2 10.6	1445.5 ± 142.9 9.9	NS	1400.4 ± 148.0 10.6
CBL, mm	38.6 ± 7.5 19.5	42.4 ± 7.5 17.6	NS	40.0 ± 7.7 19.1
CBW, g	0.20 ± 0.14 71.6	0.27 ± 0.12 44.8	NS	0.23 ± 0.16 68.9
SIL, mm	1669.2 ± 148.1 8.9	1736 ± 156.8 9.0	NS	1694.9 ± 153.5 9.0
TCL, mm	118.8 ± 7.3 6.2	113.7 ± 9.1 8.0	t = 2.23 p < 0.05	116.8 ± 8. 7.1

Note. M — males; F — females; x̄— arithmetic average; SD — standard deviation; CV — coefficient of variation; t — value of t-Student's statistics; NS — statistically insignificant differences; p — level of significance; BW — body weight; BL — body length; TL — tarsus length; SL — sternum length; EL — oesophagus length; EW — oesophagus weight; DL — duodenum length; JIL — jejunum and ileum length; CBL — combined length of both caeca; CBW — combined weight of both caeca; SIL — small intestine length intestinum tenue; TCL — combined length of intestinum terminale and cloaca.

No significant correlation relationships between the features describing black scoters' body sizes and the majority of the analysed intestine parameters were revealed — only duodenum length positively correlated with body length and weight, and terminal intestine and cloaca length with body length of the studied ducks. Both oesophagus parameters had a significant relationship with body length and weight. Moreover, oesophagus weight significantly correlated with sternum length (tabl. 3).

The analysis of the relations occurring between the studied parameters of the digestive canal of black scoters revealed a positive correlation of both parameters of caeca with small intestine length and its part — jejunum and ileum length, and a negative correlation of the measurements of those organs with oesophagus length and weight. A negative value of linear correlation coefficient was also revealed for the relation of jejunum and ileum with oesophagus weight. No relation, however, was noticed between oesophagus length with the remaining parameters of the digestive canal.

Discussion

The size of digestive organs of anseriform birds is significantly determined by the amount and type of food taken by those animals (Miller, 1975; Ankney, 1977; Paulus,

Table 2. Differences in absolute body and oesophagus and intestine parameters between immature and adult individuals of the Black Scoter *Melanitta nigra*

Таблица 2. Отличия абсолютных параметров тела, пищевода и кишечника между неполовозрелыми и взрослыми особями синьги

Measurements	x̄ ± SD CV		M_{Ad}VS. M_{Im}	x̄ ± SD CV		F_{Ad}VS. F_{Im}
	M_{Ad} (n = 27)	M_{Im} (n = 5)		F_{Ad} (n = 9)	F_{Im} (n = 11)	
BW	1350.7 ± 105.8 7.8	1320 ± 46.4 3.5	NS	1217.8 ± 74.9 6.1	1154.5 ± 84.3 7.3	NS
BL	430.9 ± 12.1 2.8	424 ± 5.5 1.3	NS	407.2 ± 13.0 3.2	406.8 ± 9.0 2.2	NS
TL	45.2 ± 1.3 2.9	45.6 ± 0.5 1.1	NS	43.1 ± 0.9 2.2	43.1 ± 1.7 3.9	NS
SL	100. 3 ± 5.9 5.9	102.7 ± 3.1 3.1	NS	94.7 ± 4.3 4.5	92.4 ± 4.6 5.0	NS
EL	173.0 ± 9.6 5.6	163 ± 10.9 6.72	t = 2.084 p < 0.05	166.1 ± 13.6 8.2	160 ± 16.3 10.2	NS
EW	7.82 ± 0.31 16.8	6.23 ± 0.47 7.6	t = 2.646 p < 0.05	7.32 ± 1.26 17.3	5.28 ± 0.49 9.3	t = 4.946 p < 0.0001
DL	309.4 ± 40.5 13.1	298 ± 23.61 7.92	NS	286.1 ± 26.1 9.1	294.1 ± 46.7 15.9	NS
CBL	37.2 ± 7.3 19.7	45.88 ± 3.3 7.3	t = −2.563 p < 0.0001	40.0 ± 6.0 14.9	44.5 ± 8.3 18.7	NS
CRW	0.16 ± 0.10 57.8	0.21 ± 0.07 32.1	t = −6.166 p < 0.0001	0.08 ± 0.02 20.3	0.15 ± 0.06 39.7	t = −3.044 p < 0.0001
JIL	1342.9 ± 135.4 10.2	1530 ± 98.2 6.4	t = 2.930 p < 0.001	1365.6 ± 105.9 7.7	1510.9 ± 139.2 9.2	t = −2.576 p < 0.05
SIL	1652.4 ± 142.8 8.6	1760 ± 158.5 9.0	NS	1651.7 ± 116.7 7.1	1805 ± 155.4 8.6	t = −2.444 p < 0.05
TCL	118.8 ± 7.5 6.3	118.7 ± 7.0 5.9	NS	113.4 ± 7.4 6.5	113.9 ± 10.7 9.4	NS

Note. M — males; F — females; ad — adult individuals; im — immature individuals; x̄ — arithmetic average; SD — standard deviation; CV — coefficient of variation; t — values of t-Student's statistics; NS — differences statistically insignificant; p — level of significance). Measurements symbols — see table 1.

Table 3. Coefficients of correlation for interdependents among linear measurment of esophagus and intestine and parameters of body in Black Scoter *Melanitta nigra* (explanation to symbols — see table 1)

Таблица 3. Коэффициент корреляции между линейными размерами пищевода и кишечника и параметрами тела у синьги

Measurements	BL	TL	SL	EL	EW	DL	JIL	CBL	CBW	SIL	TCL
BW	0.65***	0.46***	0.52***	0.48***	0.39**	0.33*	NS	NS	NS	NS	0.34*
BL	–	0.59***	0.45***	0.27*	0.43**	0.36*	NS	NS	NS	NS	NS
TL		–	0.56***	NS	0.29*	NS	NS	NS	NS	NS	NS
SL			–	NS	NS	NS	NS	NS	NS	NS	NS
EL				–	NS	NS	NS	NS	NS	NS	NS
EW					–	NS	−0.34*	−0.31*	−0.29*	NS	NS
DL						–	NS	NS	NS	NS	0.28*
JIL							–	0.45***	0.43**	0.93***	NS
CBL								–	0.52***	0.41**	NS
CBW									–	NS	NS
SIL										–	NS

* Siglificant at ≤ 0.05; ** Siglificant at ≤ 0.01; *** Siglificant at ≤ 0.001; NS — Non-sinificant.

1982; Drobney, 1984, McLelland, 1979). It was confirmed by the studies carried out by Kehoe and Ankney (1985) on a group of five diving ducks of the genus *Aythya* and by the studies of Barnes and Thomas (1987) carried out on 18 species of ducks of the genus Anatidae. Those researchers recorded a positive relationship between the length of intestine and its individual parts and the amount of food rich in fibre taken by the birds. Species of ducks feeding on animal food usually had (relatively to body weight) shorter or lighter small intestine and caeca. The Black Scoter *Melanitta nigra* is rated among predatory ducks. It eats small amounts of vegetable food only in summer. The studied group of black scoters was obtained in winter, in the period when the birds exclusively feed on animal food. However, as for a predatory species, the studied black scoters had quite long small intestine (1694.9 mm) relatively to body weight (1283.3 g). Goudie and Rayan (1991) obtained similar results studying 17 wintering individuals of this species — at the average body weight of 1038.4 g the small intestine of those birds was 1562 mm long. For comparison, in 99 individuals of vegetable eating Mallard *Anas platyrhynchos* with comparable body weight to the studied black scoters (1182.6 g), small intestine length was 1614.2 mm (Działa-Szczepańczyk, 2001). But in 25 individuals of predatory King Eider *Somateria spectabilis* with the average body weight of 1425.2 g, the small intestine was also long — 1871 mm (Goudie, Rayan, 1991). The presence of very short caeca draws attention in the alimentary system of the Black Scoter — the combined average length of those organs in the studied group of birds was 40 mm. Similar values of this parameter (42 mm) were obtained for 24 wintering individuals of this species (Goudie, Rayan, 1991). Presumably, such small sizes of caeca in the Black Scoter are connected with the diet — birds of this species feed on highly concentrated and little varied food, consisting mainly of bivalves (Madsen, 1954; Stempniewicz, 1986; del Hoyo et al., 1992)

Dimorphic differences in body size of the studied black scoters were revealed, but at the same time, no such differences were recorded in most intestine measurements. Ontogenetic differences were not visible in body measurements of black scoters, but they were noticed in the size of the analysed elements of alimentary system. Those results can confirm a certain regularity noticed by Pulliainen (1976) studying digestive organs of wintering Willow Grouse *Lagopus lagopus*. This author stated that lighter individuals of this species (females and young individuals) had relatively longer small intestines and caeca than heavier birds (males and adult individuals). Pulliainen (1976) put forward a thesis that smaller birds must eat more food than bigger individuals to satisfy bigger energy demand in this season of the year, which results in the lengthening of their intestine. Miller (1974) studying captive Mallards *Anas platyrhynchos* stated that females of this species had longer intestine than males, although the birds of both sexes fed on similar food. This researcher (Miller, 1974) put forward a presumption that ducks of this species may have genetically conditioned better ability to adapt to diet change than drakes. Similarly Moss (1972), studying the Red Grouse *Lagopus lagopus scoticus* — kept in captivity for several generations — claimed that differences in small intestine length between females and males of this species may have genetic basis. In each next generation of the studied birds the small intestine got shorter in both sexes, but this organ in the first generation was longer in females than in males, and in next generations the situations changed — males were characterised by longer small intestine than females. According to Moss (1972), those changes were results of the selection in the direction of forming optimum small intestine length adjusted to more concentrated food. Dimorphism in small intestine length was also revealed in the Bean Goose *Anser fabalis*. Females of this species had relatively (with relation to body weight) longer small intestine than males (Szczepańczyk et al., 2000).

The recorded dimorphism in the studied group of black scoters referring to oesophagus length and weight may be a consequence of differences in body weight between

individuals of both sexes. Moreover, it may show less morphological plasticity of this organ with reference to changes of a diet in time, which in turn may be a result of the function performed by the oesophagus in the digestive canal — this organ, contrary to the intestine, does not play an important role in digestive and absorption processes. Sexual dimorphism in oesophagus length was also observed in 64 individuals of the Bean Goose *Anser fabalis* (Szczepańczyk et al., 2000), in which bigger males also had longer and heavier oesophagus than smaller females. However, the differences between males and females of this species in the relative oesophagus length referring to body length and sternum length, turned out to be insignificant. In case of 15 individuals of Red-Necked Grebe *Pediceps griseigena* significant differences between both sexes were recorded both in absolute and relative oesophagus length (related to body length). Females were characterised by higher values of those parameters (Szczepańczyk, 1999).

Most of significant relationships between body measurements of the studied black scoters and the analysed parameters of the digestive canal were recorded in case of oesophagus weight. Similar relationship, but in relation to the length of this organ and body parameters was revealed in the Bean Goose *Anser fabalis* (Szczepańczyk et al., 2000). The intestine parameters of the studied black scoters, contrary to oesophagus parameters, in most cases did not show significant relationships with body measurements. It may indicate a bigger morphological stability of oesophagus in comparison to intestine, which was mentioned earlier. Similar results — the lack of relationships of most intestine parameters with the measurements describing body size — were obtained for some Anseriforms species — for the Velvet Scoter *Melanitta fusca* (Szczepanczyk, 1998), White-Fronted Goose *Anser albifrons* (Szczepańczyk et al., 1999), Bean Goose *Anser fabalis* (Szczepańczyk et al., 2000) and the Domestic Duck of Peking breed *Anas platyrhynchos* f. *domestica* (Działa-Szczepańczyk, 2001). In the Mallard *Anas platyrhynchos* a significant relationship was recorded of duodenum length with all three body parameters: body length and weight, and sternum length (Działa-Szczepańczyk, 2001).

A positive value of correlation coefficient for the relationship of both caeca length with jejunum and ileum length, recorded in individuals of the studied group of black scoters, was also obtained for other species of the family of *Anatidae*: the Velvet Scoter *Melanitta fusca* (Szczepańczyk, 1998), Mallard *Anas Platyrhynchos* — in both forms — domesticated and wild (Działa-Szczepańczyk, 2001), and for the White-Fronted Goose *Anser albifrons* (Szczepańczyk et al., 1999). Presumably, caeca in those species react similarly to jejunum and ileum to changes in diet and transform morpho-anatomically in a similar pace.

Conclusions

1. Despite the revealed significant dimorphic differences in features describing body sizes of black scoters, significant differences between females and males were recorded only in relation to oesophagus length and weight, and rectum and cloaca length.

2. Ontogenetic differences concerning body size of black scoters within each sex were not visible. But such differences were revealed in both groups of males and females in relation to oesophagus weight, jejunum and ileum length, and caeca weight.

3. A positive correlation for the relationship of caeca with small intestine length and a negative correlation for the relationship of oesophagus weight with both caeca parameters and with jejunum and ileum length were revealed.

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